



Executive Summary

This report is intended to meet the requirements of the California Government Code Sections 51015 and 51016. It analyzes the risks associated with California's 7,800 miles of regulated hazardous liquid pipelines utilizing leak incident data from January 1981 through 1990.

The study was conducted by EDM Services, Inc. of Simi Valley, California. Brian L. Payne served as project manager and authored the report, except for Section 5.0 which he co-authored. Dr. Michael O'Rourke co-authored Section 5.0 and performed the seismic risk analysis. Shawn Kanaiaupuni performed the statistical analyses.

Extensive efforts were taken to collect data which would allow the results to be presented in meaningful units. The resulting incident rates have been presented in units of *incidents per 1,000 mile years*. This unit provides a means of predicting the number of incidents expected for a given length of line, over a given period of time. For example, if one considered an incident rate of 1.0 incidents per 1,000 mile years, one would expect one incident per year on a 1,000 mile pipeline. Using this unit, frequencies of occurrence can be calculated for any combination of pipeline length and time interval.

Using all available data, the overall incident rates for various pipeline events have been estimated as follows:

California Regulated Hazardous Liquid Pipelines
January 1981 through December 1990 Data

Event	Incident Rate
any size leak	7.1 incidents per 1,000 mile years
damage greater than \$5,000	1.3 to 6.2 incidents per 1,000 mile years
damage greater than \$50,000	up to 4.4 incidents per 1,000 mile years
any injury, regardless of severity	0.70 injuries per 1,000 mile years
injury requiring hospitalization	0.10 injuries per 1,000 mile years
fatality	0.02 to 0.04 fatalities per 1,000 mile years

The primary study findings are summarized below and are detailed in the paragraphs which follow:

- Pipelines within 500' of a rail line do not pose a higher risk than those located farther from a railroad.
- External corrosion caused 59% of the leak incidents, followed by third party damage which caused 20%.
- Older pipe and pipelines operated at elevated operating temperatures had significantly higher leak incident rates, primarily affected by increased external



corrosion incident rates.

Little benefit was found to be associated with the cost of adding additional block valves to California's regulated hazardous liquid pipeline network.

The results indicated a decreasing incident rate trend during the ten year study period. The ordinary least squares line of best fit indicated that *the incident rate was decreasing at the rate of 0.52 incidents per year, per 1,000 mile years of pipeline operation during the study period.* This represents roughly a 7% annual reduction in the number of leak incidents for each year during the study period.

On the other hand, the average cost of damage per incident (including property damage, clean-up, hazardous material disposal, etc.) increased significantly during the ten year period. After normalizing the data to constant 1983 US dollars, the ordinary line of best fit indicated that the average cost per incident increased at the rate of \$33,040 (\$US 1983) per year. The average damage during the study period was \$141,000 per incident. This represents an annual damage cost increase of over 20% per year during the study period. The high average cost, combined with the increasing damage cost trend, have likely provided industry with significant incentives to implement programs aimed at minimizing the potential for hazardous liquid pipeline incidents.

It is important to note that there was a huge difference between the average and median damage values. While the average figure was \$141,000, the median value was only \$7,200 (\$US 1983). Further, 75% of the leak incidents resulted in damage of \$38,000 or less. This enormous difference between the average and median values, as well as the other data collected, indicates that a few very costly incidents greatly affected the average value. Specifically, only slightly more than 10% of the incidents resulted in damage greater than the average value.

We did not find a difference between the incident rates for pipelines within 500' of a rail line and pipelines away from rail lines. The specific incident rates for these lines were 6.79 and 6.96 incidents per 1,000 mile years respectively. The data does not indicate that the unfortunate 1989 San Bernardino train derailment was anything but an isolated incident. Similar accidents have resulted from incidents caused by other forms of third party damage, external corrosion, etc. As a result, we do not see a need for additional regulations regarding pipelines near railroad rights-of-way. Further, data available from the National Transportation Safety Board and the Department of Transportation indicate that pipelines are the safest mode of freight transportation. Costly new pipeline regulations would likely result in some volume of pipeline traffic being diverted to a less safe transportation mode. This could result in a net decrease in transportation safety.

94% of the injuries and 100% of the fatalities resulted from only three incidents (only 0.58% of the total number of incidents). Each of these incidents had a different cause. Although the number of incidents was too small to draw any meaningful conclusions, it was interesting to note that all of the injuries and fatalities occurred on petroleum product lines; no injuries or fatalities were observed on crude oil pipelines. (Once again, the reader should be cautioned from drawing any potentially misleading conclusions from this limited data sample.)

External corrosion was by far the largest cause of leak incidents, representing 59% of the total. In recent years, industry and regulatory efforts have focused on preventing third party damage. It may be prudent to redirect some of these efforts and/or increase efforts to reduce external



corrosion. Pipe age and operating temperature were found to clearly affect external corrosion leak incident rates. As a result, these factors should receive special attention in any future work. In this study, significant differences in external corrosion leak incident rates were found among the following factors:

- Older pipelines had a significantly higher external corrosion leak incident rate than newer lines.
- Elevated pipeline operating temperatures significantly increased the frequency of external corrosion caused leaks.
- Intrastate lines had a higher external corrosion leak incident rate than interstate pipelines. However, the intrastate lines were generally much older and operated at a higher mean operating temperature.
- Non-common carrier lines (those which generally do not transport hazardous liquids for hire) had a higher external corrosion leak incident rate than common carrier pipelines. But the non-common carrier lines operated at a higher mean operating temperature and were older.
- Crude oil pipelines had a much higher external corrosion leak incident rate than petroleum product pipelines. Once again however, crude pipelines had a much higher mean operating temperature and were slightly older.
- Pipelines within standard metropolitan statistical areas (SMSA's) had a higher external corrosion leak incident rate than pipelines in non-SMSA's.
- The external corrosion leak incident rate was less for pipelines greater than 16" in diameter than it was for smaller lines.
- Although a small sample, pipelines without cathodic protection systems had a drastically higher frequency of external corrosion caused leaks than protected lines.
- In some cases, the pipe specification and type of external corrosion coating affected external corrosion leak incident rates.

Pipe age and operating temperature had a significant effect on the resulting overall incident rates; older pipe and pipelines operated at elevated temperatures had significantly higher incident rates. For example, pipelines constructed before 1940 had a leak incident rate roughly 20 times higher than pipelines constructed in the 1980's. The majority of this difference was due to differences in the external corrosion rates. In addition, pipelines operated above 130°F had external corrosion incident rates 8 to 23 times higher than pipelines operated at ambient temperatures.

It is likely that many of the older lines included in the study had inadequate cathodic protection, by current standards, during their early years of operation. The regulatory requirements for these lines has increased during their operating life. For instance, although some interstate line regulations date back to 1908, many externally coated interstate lines were not required to be cathodically protected until 1973; many externally coated intrastate lines were not required to have



protection until 1988. Further, intrastate lines operating by gravity or less than 20% SMYS were not required to have cathodic protection until 1991.

The overall leak incident rate for pipelines within standard metropolitan statistical areas (SMSA) was over three times higher than for non-SMSA areas. However, the average damage and spill size for incidents within SMSA's was less than one-third the figures for non-SMSA's. As one might expect, pipe within SMSA's experienced a higher rate of incidents caused by third party damage, 1.51 versus 0.81 incidents per 1,000 mile years. However, the vast majority of the difference between SMSA and non-SMSA leak incident rates resulted from external corrosion; the external corrosion incident rate within SMSA's was nearly five times greater than for non-SMSA's. Unfortunately, a detailed analysis of these data was beyond the scope of this study. Further study may be warranted to further explore these differences. If further study is performed, it should analyze the possibility of a relationship between the differences in interstate versus intrastate pipeline incident rates and those of SMSA's and non-SMSA's.

Little if any statistical correlation was found between spill size and block valve spacing. We found that 50% of the spill volumes represented only 0.75% of the pipeline volume between adjacent block valves; 80% of the spill volumes were less than 8.5% of the pipeline volume between adjacent block valves. These and other data indicated that other factors (e.g. local terrain, low leak rates, etc.) considerably affected spill volumes. However, a cost benefit analysis was performed using the ordinary least squares line of best fit data anyway. The results indicated little benefit relative to the associated costs for adding any significant number of block valves to the existing California regulated hazardous liquid pipeline network. However, we found that there may be some line segments over about 10 miles long which may benefit from intermediate block valves. These segments must be evaluated individually, considering local terrain and other effects, before any further conclusions can be drawn.

Our survey of pipeline operators and local fire departments yielded a consensus that notifying local affected fire agencies each time pipeline fluid contents changed would not result in significant benefits. The fire departments surveyed indicated that their current programs and contingency plans were adequate to handle foreseen emergencies.

We anticipate somewhere between 13 and 29 leak incidents caused by seismic activity on regulated California hazardous liquid pipelines during a future 30 year period. By simply extrapolating injury and fatality data collected in this study, we would expect seismic activity to cause between one and three injuries and have between a 1 in 6 and 1 in 13 likelihood of causing a fatality during the same future 30 year period. However, the reader should note that the injury and fatality extrapolations were based on a very limited data sample; their statistical relevance is very limited. Further, for the purposes of this study, data were included in the injury category, regardless of severity; these included injuries which required only minor on-site medical treatment and/or observation. As a result, we expect that any injury data presented herein is conservative, when compared to more typical injury definitions.

We did not find a statistical correlation between normal operating pressure and the probability of rupture.